TES PROGRAM STATUS

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Harvard University
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AURA Science Team Meeting, PASADENA, CA Oct 1-5 2007

The TES Experiment

Global measurements of tropospheric ozone and its precursors from TES combined with *in-situ* data and model predictions will address the following key questions:

How is the increasing ozone abundance in the troposphere affecting

- ***air quality on a global scale?***
- ***oxidizing reactions that "cleanse" the atmosphere?***
- ***climate change?***

TES Operating Modes

Global Survey: **16 orbits of nadir & limb observations repeated every other day. This is the source of Standard Products.**

Stare: **Point at a specific latitude & longitude for up to ~4 minutes.**

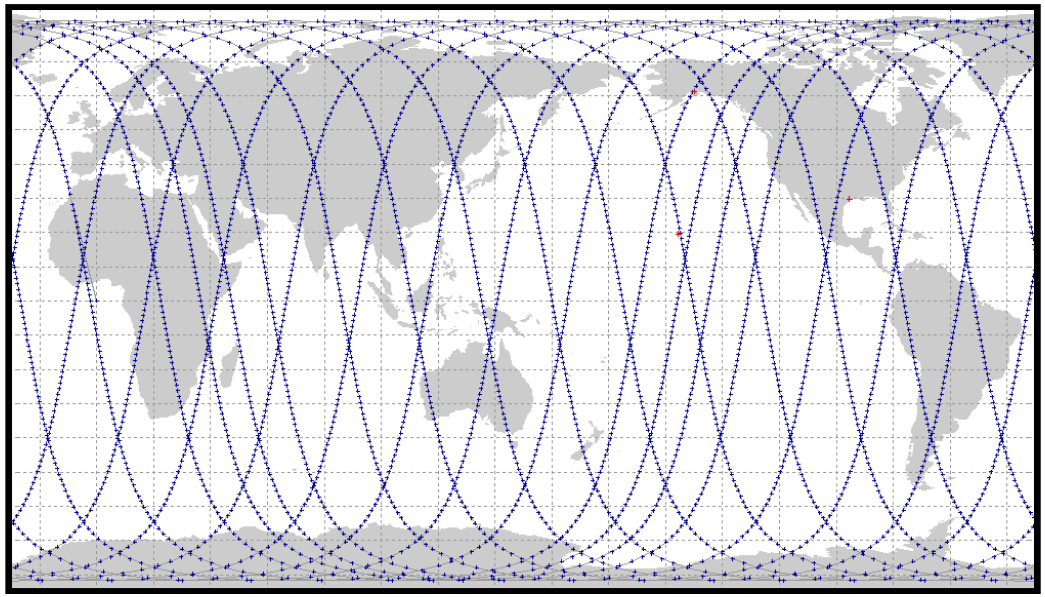
Transect: **Point at a set of contiguous latitudes & longitudes to cover ~450 km.**

Step-&-Stare: **Point at nadir for 4 seconds (5.2 seconds with necessary reset). Spacecraft has moved ~40 km. Point at nadir again. Repeat indefinitely.**

Limb Drag: **Point at the trailing limb (16 second scans). Repeat indefinitely.**

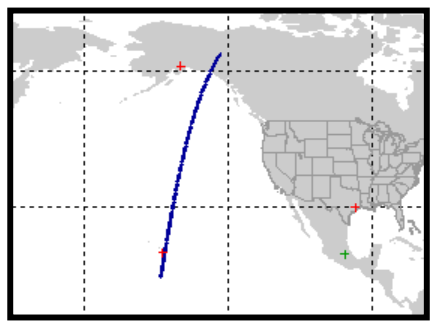
These last 4 modes constitute Special Products that are obtained *only* when no Global Survey is scheduled.

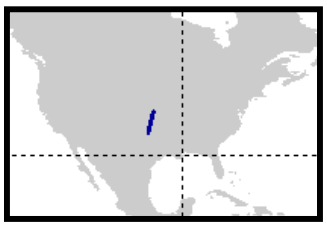
Examples of TES nadir coverage



Global Survey footprints
180 km apart
Every 2 days… 312 and counting

Step/Stare footprints
45 km apart
Special observation





Transect footprints
Contiguous!
Special observation

Project Highlights

01-08-07	Release 10 Operational at SIPS
01-15-07	Begin Release 10 Nadir reprocessing
01-24-07	Fifteenth Detector de-ice Jan. 24-26, 2007
01-29-07	Begin seven week SO collection in Sweden to support of SAUNA ozone validation campaign
04-19-07	Initial release of Level 3 PGE delivered to SIPS
04-28-07	Begin Release 10 Limb reprocessing
04-22-07	Begin ten week SO collection of US-Mexico Border to observe pollution events
06-11-07	Sixteenth Detector de-ice June 11-13, 2007
07-01-07	Begin nine week SO collection of Beijing to study pollution outflow
07-04-07	Begin seven week SO collection of North America to measure summertime pollution and support WAVES_2007
07-15-07	Begin four week SO collection of SO's supporting TC-4 in Costa Rica
07-27-07	Delivered Level 2 PGE point build supporting SCF full filter processing
08-04-07	Filter Wheel Anomaly

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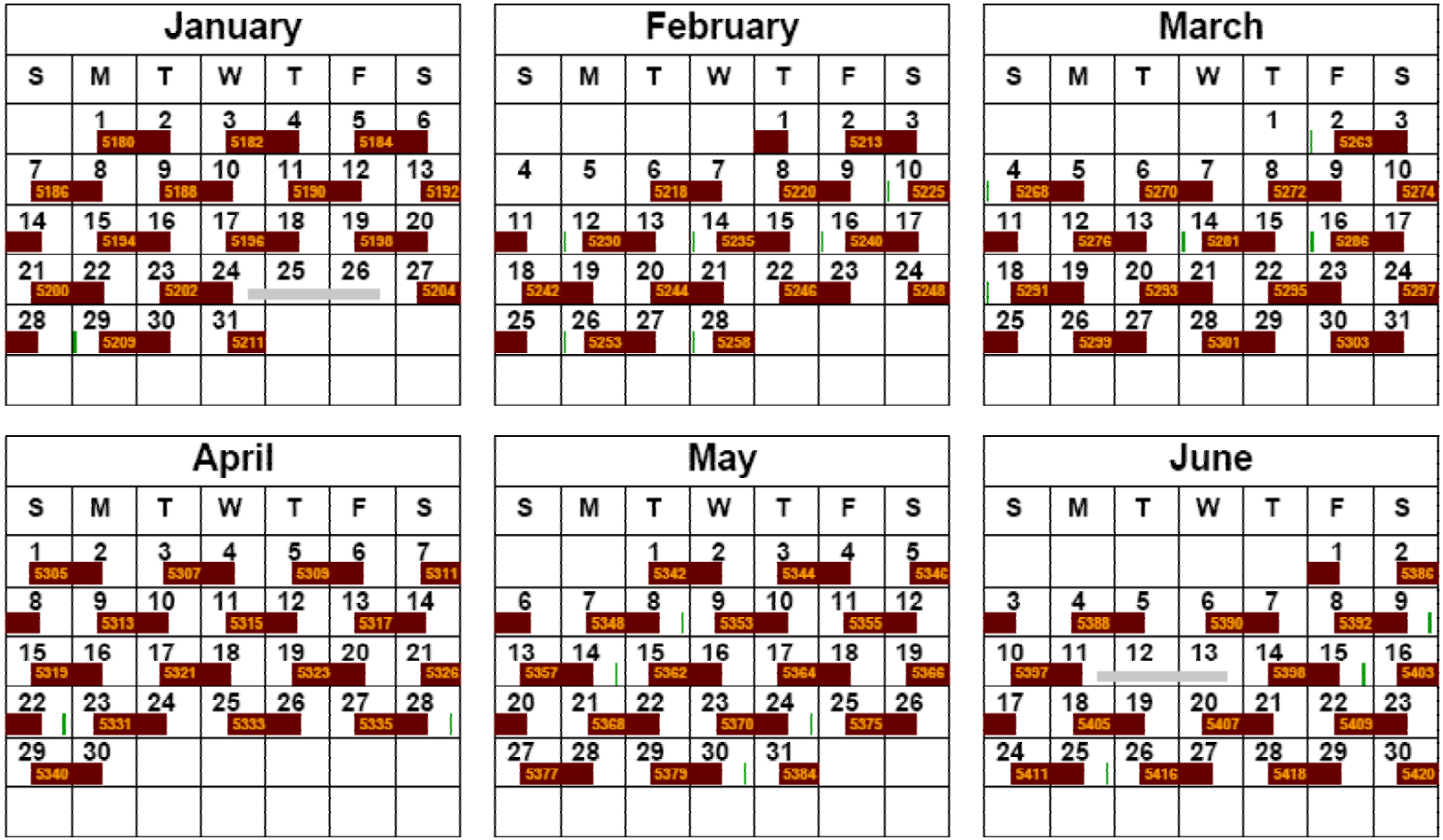
Tropospheric Emission Spectrometer

TES Science Observations and Level 2 Products
January through June 2007



Available Global Surveys: Dull Red = GS (V003, R10) Faded Green = GS (V002, R9.3)
Available Special Observations: Red = Step&Stare Green = Transect Magenta = Stare Violet = Limb
Dark Gray = L2 Product Not Available Orange = RunID for Global Survey Light Gray = Focal Plane De-Ice

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Tropospheric Emission Spectrometer

TES Science Observations and Level 2 Products
July through December 2007

July

S	M	T	W	T	F	S
1	2 5449	3	4 5478	5	6 5507	7
8 5542	9	10 5571	11	12 5600	13	14 5629
15	16 5648	17	18 5677	19	20 5706	21
22 5735	23	24 5770	25	26 5802	27	28 5831
29	30 5860	31				

August

S	M	T	W	T	F	S
			1 5889	2	3 5918	4
5	6	7 5948	8	9 5983	10	11 6015
12	13 6044	14	15 6073	16	17 6102	18
19 6131	20	21 6160	22	23 6189	24	25 6220
26	27 6253	28	29 6282	30	31 6311	

September

S	M	T	W	T	F	S
						1
2 6313	3	4 6315	5	6 6317	7	8 6319
9	10 6324	11	12 6323	13	14 6334	15
16 6336	17	18 6338	19	20 6340	21	22 6342
23	24 6344	25	26 6346	27	28 6348	29
30 6350						

October

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

November

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

December

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

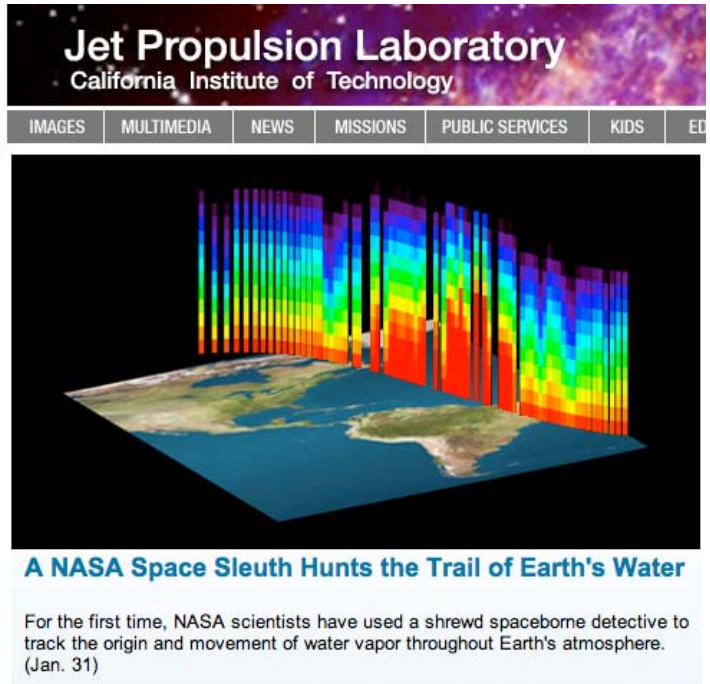
All UTC Time: Blue = Global Survey Red = Step&Stare Green = Transect Magenta = Stare Violet = Limb
Orange = RunID for Global Survey Gray = Focal Plane De-Ice

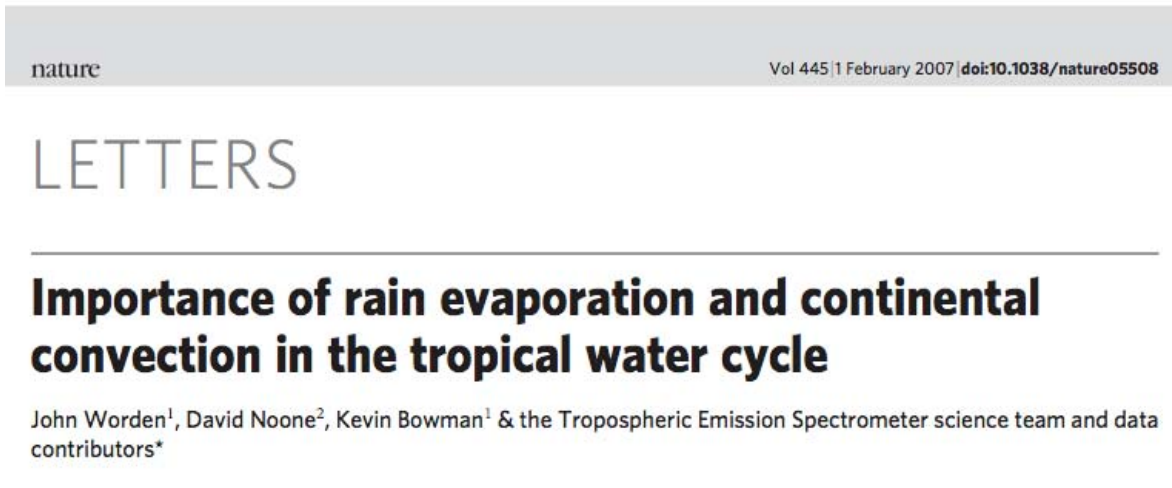
Instrument Highlights

- All subsystems continue to operate nominally
- TES completed three years of on-orbit operations July 15, 2007
- ICS average motor current during Global Surveys continues a gradual upward trend
- ICS Action Plan remains unchanged
  - If ICS mean/peak current becomes unacceptable (value under analysis) or ICS mechanism stalls:
    1) Warm motor/encoder to 25°C, execute several long scans, cool and continue
    2) Increase coarse motor voltage setting
- A Filter Wheel Anomaly occurred on August 4, 2007 - Instrument Operations resumed within 48 hours
- Summary of ICS Electronics and Fault Management Study
  - ICS Motor and Electronics both capable of running at high current without damage
  - ICS motor overcurrent monitoring has conversion limitation
  - A plan is underway to modify the Fault Threshold Table to enable the Flight software to correctly measure ICS overcurrents greater than 2.1 amps

Water Vapor Cycle

- Measuring the ratio of water and heavy water (HDO) tells about the evaporation processes in the atmosphere.
- We learn about the intensity of the hydrological cycle, or evaporation and condensation processes.
- Nature paper by J. Worden, D, Noone, K. Bowman et al. (2/2007), JPL press release





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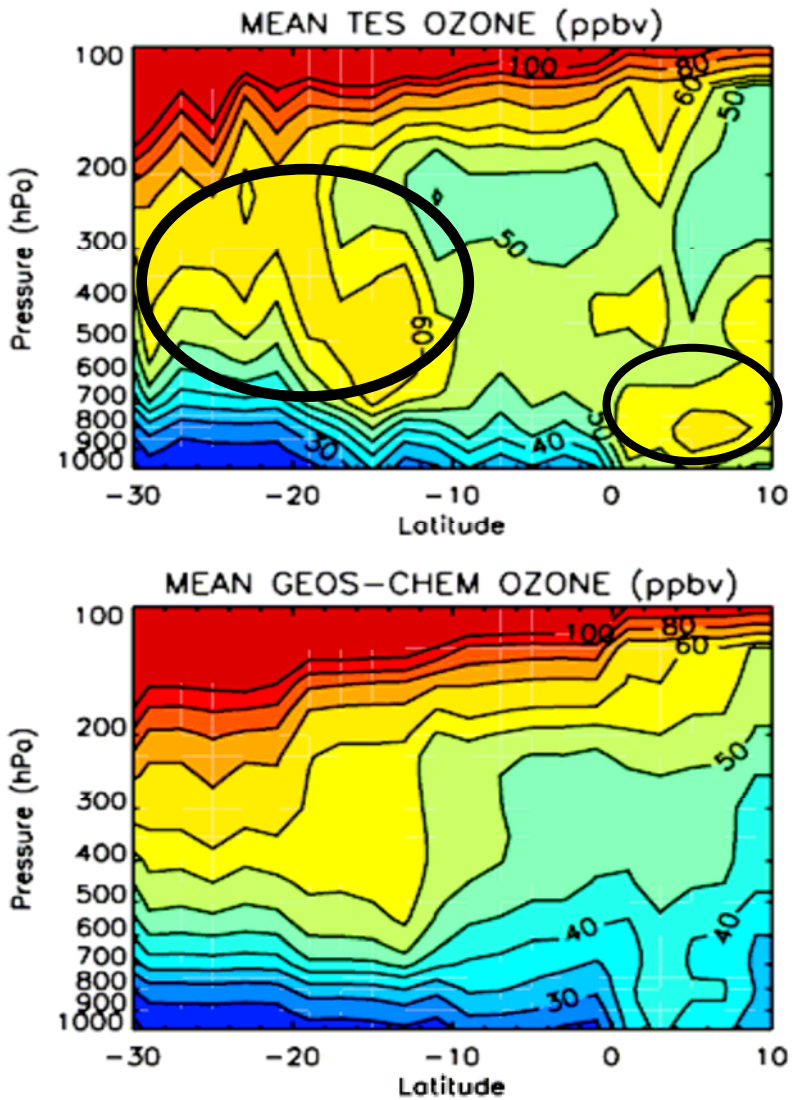
TES observes elevated lower tropospheric ozone



(L. Jourdain et al. GRL, 2007)

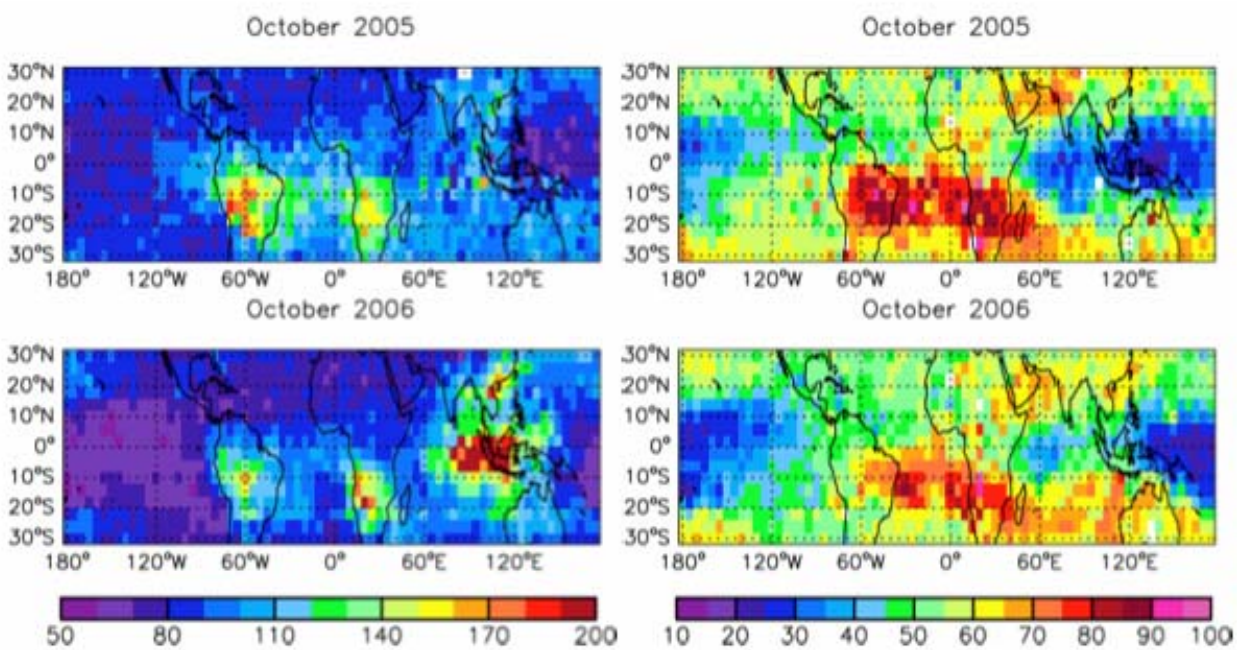
Problem: Understanding the distribution of tropospheric ozone, and controlling processes.

Result: TES observations show high concentrations of *upper* tropospheric ozone south of the ITCZ, and high concentrations of *lower* tropospheric ozone north of the ITCZ.

Significance: First space-borne measurement to differentiate ozone layers of the troposphere. These observations are being used to improve estimates of the impact of biomass burning on tropospheric ozone.

ENSO effects on trop composition

- Jennifer Logan et al, The effects of the 2006 El Niño on tropospheric composition as revealed by data from the Tropospheric Emission Spectrometer (TES)
- Fire emissions, associated with low rainfall, and dynamical impacts of the El Nino created marked differences in CO and O3 fields between 2006 and 2005.



CO (ppb) **Ozone (ppb)**

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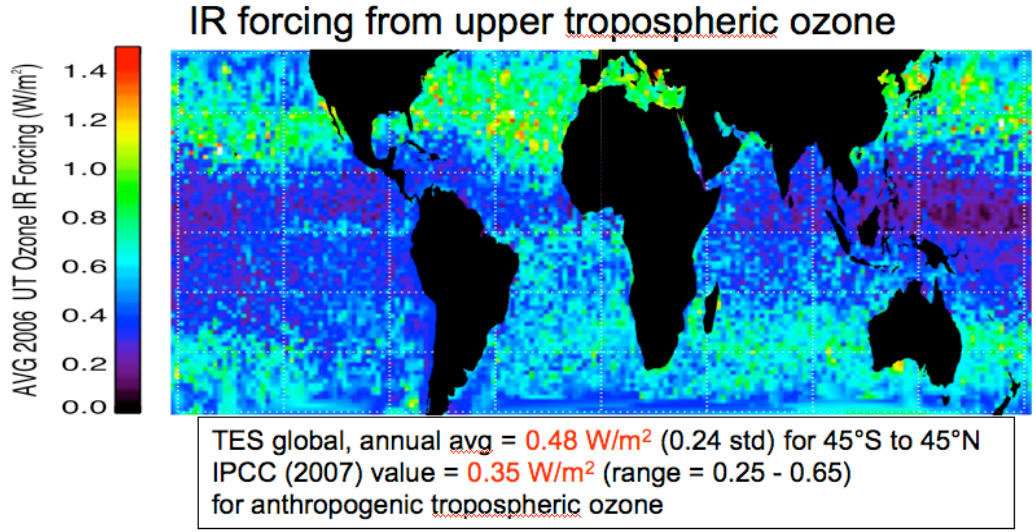
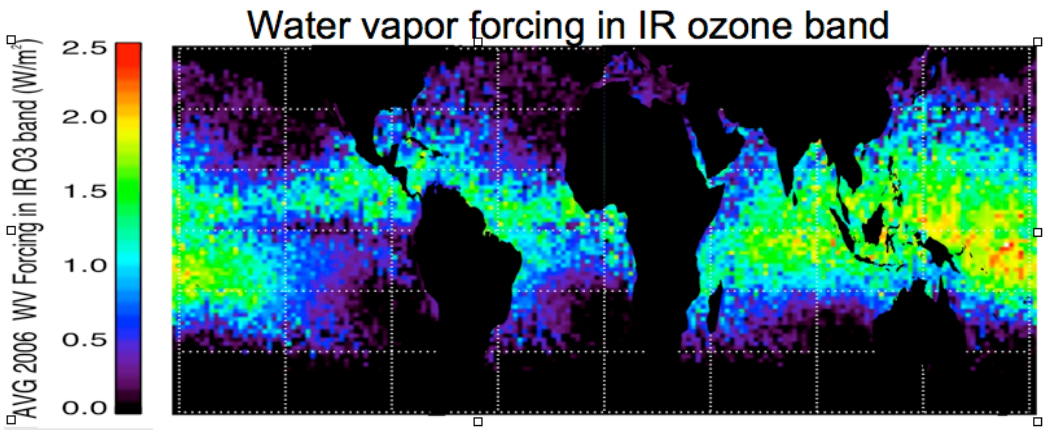
Tropospheric Emission Spectrometer

TES observations of IR radiative forcing





Problem: Radiative forcing of tropospheric ozone is modeled, but not measured. Tropospheric ozone is important in total radiative budget and uncertain in the future.

Result: **TES** observations used to quantify the observed IR forcing of tropospheric ozone and water vapor in the ozone band.

Significance: First space-borne measurement of tropospheric ozone forcing. TES observations are in the range of model forecasts, but show more sensitivity of IR forcing in the Northern Hemisphere than models.

(**H. Worden et al. in prep, 2007)**

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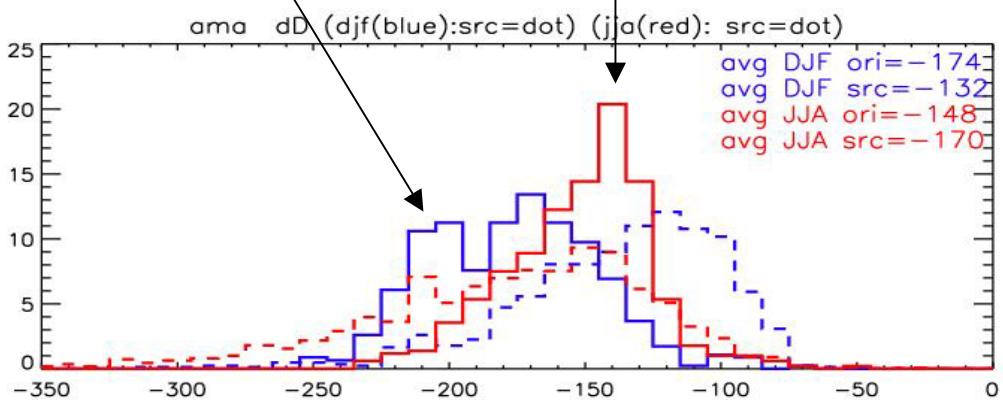
Amazon Rainy Season Water Budget

Back Trajectories from most depleted vapour observations (blue histograms) show condensation and re-evaporation history associated with Andes Mountains and source region North of Brazil

Least depleted vapour observations (red histograms) show direct transport from oceanic source with little condensation history.

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.



(Brown, Worden, Noone, to be submitted)

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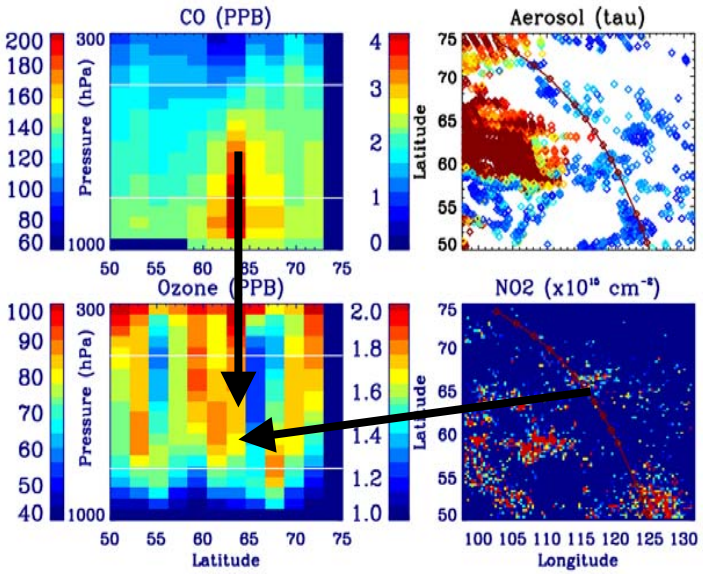
Tropospheric Emission Spectrometer

Enhanced and Depleted Ozone in Boreal Fire Plume

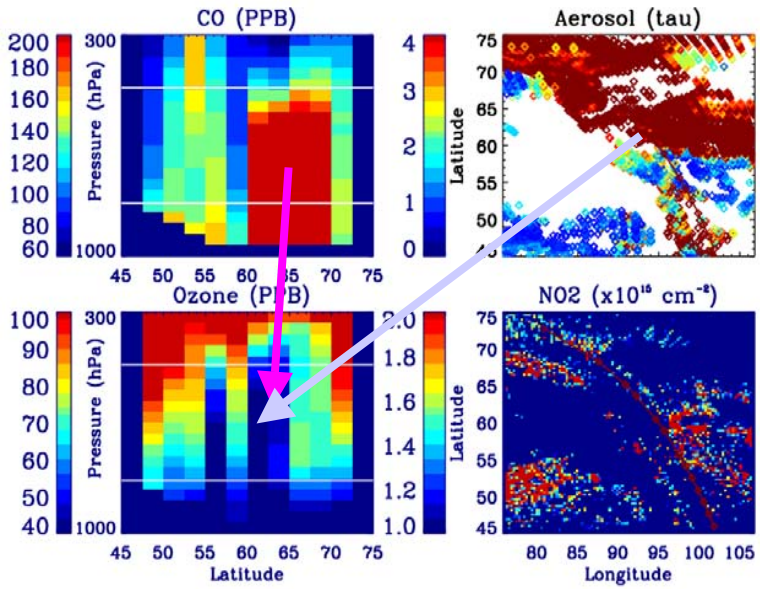
Case (a) TES O_3/CO 24th July 2006



TES OMI

Ozone production in Fire smoke plumes is highly variable

Case (b) TES O_3/CO 24th July 2006



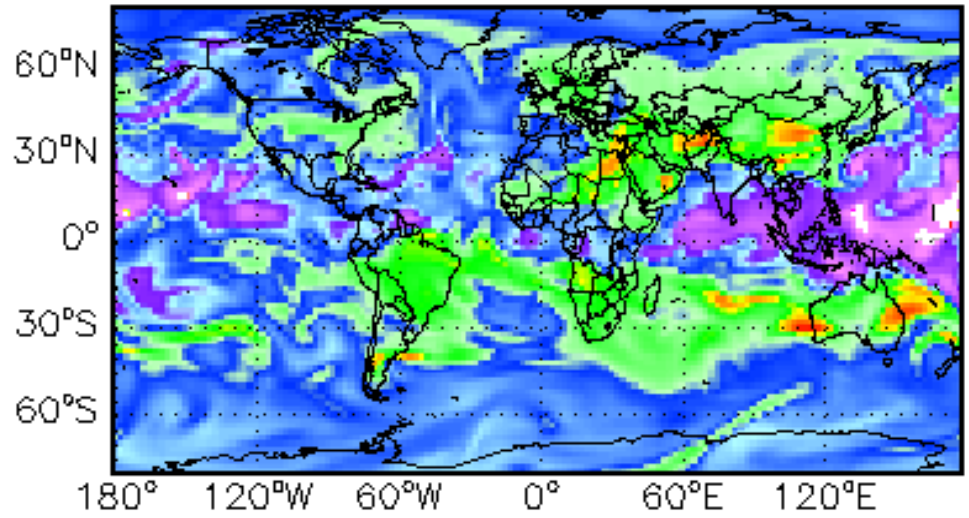
TES OMI

Figure: Ozone and CO as observed by TES; Aerosol optical depth, and NO2 tropospheric column amounts as observed by OMI for Siberian Boreal fires are depicted in the above Figures Figure (a) shows enhanced ozone, CO and NO2 in a relatively fresh part of the smoke plume and Figure (b) shows reduced ozone, despite of presence of CO, and NO2 under similar conditions but in the presence of optically thick aerosol amounts .

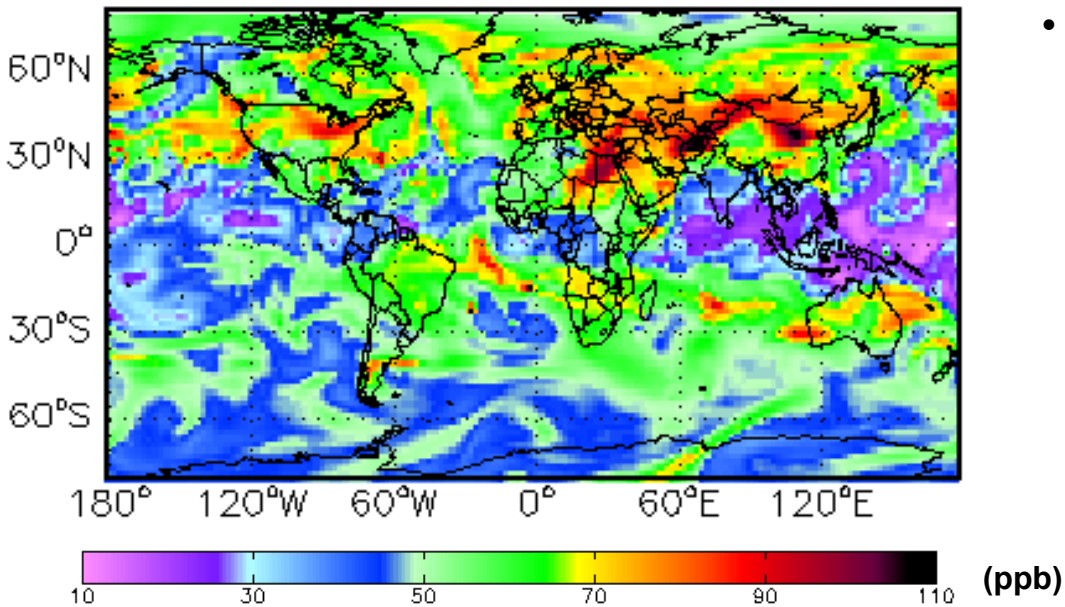
Aerosols have a significant impact on the ozone photochemistry in the boreal fires.

Verma et al, in prep

AM2-Chem at 5 km 15 Aug 2006 (with nudged dynamics)



AM2-Chem at 5 km after assimilation of TES O_3



Assessing the response of the dynamics in AM2-Chem to the assimilation of TES O_3

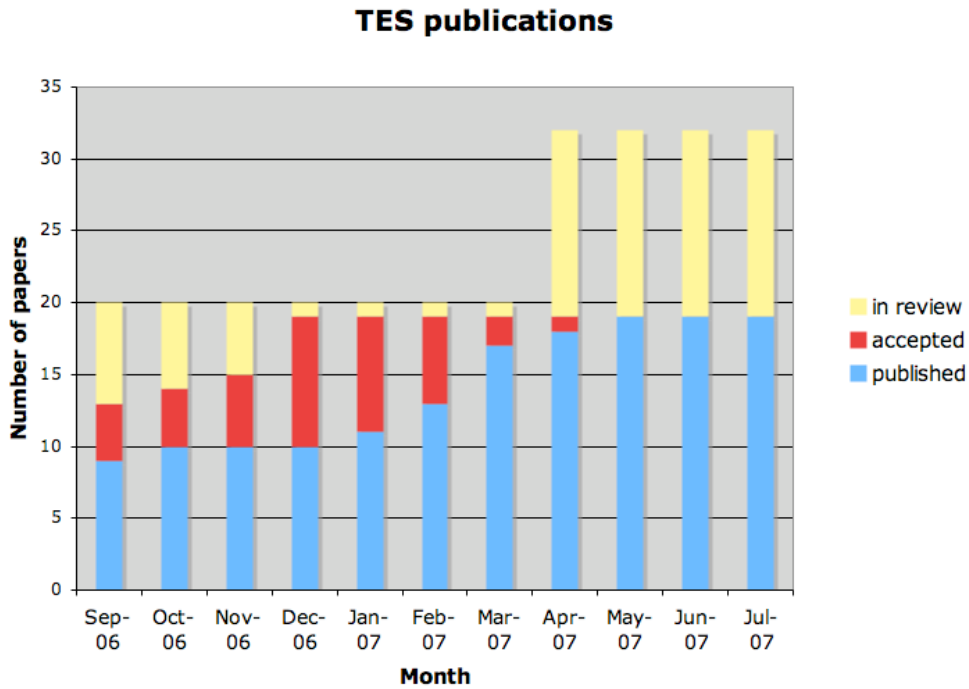
Approach

- Assimilate TES O_3 in AM2-Chem
- Impose optimized O_3 fields in the radiation calculation in the free running GCM to examine response of dynamics to the O_3 heating

D. Jones, et al., in prep

Ongoing Collaborations & Pubs

- Brad Pierce (NOAA-NESDIS)
- Jay Al-Assadi (NASA Langley)
- Dylan Jones (Univ. Toronto)
- David Noone (Univ. Colorado)
- Larry Horowitz (GFDL)
- Mary Barth (NCAR)
- Helen Worden (NCAR)
- Ken Pickering (Goddard)
- Qinbin Li (JPL)
- EPA Region 9
- Nigel Richards (Univ. Leicester)
- Jenny Moody (Univ. Virginia)
- Henry Fuelberg (Florida State)
- Adrian Sandu (Virginia Tech)
- Kelly Chance & Xiong Liu (SAO)
- Texas Commission on Environmental Quality (TCEQ)



- Harvard crowd
- MLS team
- Jae Kim